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Second edition
2005-04

Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval

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CRYSTALLINE SILICON TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – DESIGN QUALIFICATION AND TYPE APPROVAL

FOREWORD

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International Standard IEC 61215 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This second edition cancels and replaces thew first edition published in 1993 and constitutes a technical revision.

The main changes with respect to the previous edition (published in 1993) are detailed in Annex A.

The text of this standard is based on the following documents:

FDIS	Report on voting
82/376/FDIS	82/382/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

CRYSTALLINE SILICON TERRESTRIAL PHOTOVOLTAIC (PV) MODULES – DESIGN QUALIFICATION AND TYPE APPROVAL

1 Scope and object

This International Standard lays down IEC requirements for the design qualification and type approval of terrestrial photovoltaic modules suitable for long-term operation in general open-air climates, as defined in IEC 60721-2-1. It applies only to crystalline silicon modules types. A standard for thin-film modules has been published as IEC 61646.

This standard does not apply to modules used with concentrated sunlight.

The object of this test sequence is to determine the electrical and thermal characteristics of the module and to show, as far as is possible within reasonable constraints of cost and time, that the module is capable of withstanding prolonged exposure in climates described in the scope. The actual lifetime expectancy of modules so qualified will depend on their design, their environment and the conditions under which they are operated.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

IEC 60068-2-21:1999, *Environmental testing – Part 2-21: Tests – Test U: Robustness of terminations and integral mounting devices*

IEC 60068-2-78:2001, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60410:1973, *Sampling plans and procedures for inspection by attributes*

IEC 60721-2-1:1982, *Classification of environmental conditions – Part 2: Environmental conditions appearing in nature – Temperature and humidity*

IEC 60891:1987, *Procedures for temperature and irradiance corrections to measured I-V characteristics of crystalline silicon photovoltaic devices*
Amendment 1 (1992)

IEC 60904-1:1987, *Photovoltaic devices – Part 1: Measurements of photovoltaic current-voltage characteristics*

IEC 60904-2:1989, *Photovoltaic devices – Part 2: Requirements for reference solar cells*

IEC 60904-3:1989, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 60904-6:1994, *Photovoltaic devices – Part 6: Requirements for reference solar modules*

IEC 60904-7:1998, *Photovoltaic devices – Part 7: Computation of spectral mismatch error introduced in the testing of a photovoltaic device*

IEC 60904-9:1995, *Photovoltaic devices – Part 9: Solar simulator performance requirements*

IEC 60904-10:1998, *Photovoltaic devices – Part 10: Methods of linearity measurements*

IEC 61853: *Performance testing and energy rating of terrestrial photovoltaic (PV) modules* [1]

ISO/IEC 17025:1999, *General requirements for competence of testing and calibration laboratories.*

3 Sampling

Eight modules for qualification testing (plus spares as desired) shall be taken at random from a production batch or batches, in accordance with the procedure given in IEC 60410. The modules shall have been manufactured from specified materials and components in accordance with the relevant drawings and process sheets and have been subjected to the manufacturer's normal inspection, quality control and production acceptance procedures. The modules shall be complete in every detail and shall be accompanied by the manufacturer's handling, mounting and connection instructions, including the maximum permissible system voltage.

If the bypass diodes are not accessible in the standard modules, a special sample can be prepared for the bypass diode thermal test (10.18). The bypass diode should be mounted physically as it would be in a standard module, with a thermal sensor placed on the diode as required in 10.18.2. This sample does not have to go through the other tests in the sequence depicted in Figure 1.

When the modules to be tested are prototypes of a new design and not from production, this fact shall be noted in the test report (see Clause 8).

4 Marking

Each module shall carry the following clear and indelible markings:

– name, monogram or symbol of manufacturer;
– type or model number;
– serial number;
– polarity of terminals or leads (colour coding is permissible);
– maximum system voltage for which the module is suitable.

The date and place of manufacture shall be marked on the module or be traceable from the serial number.

[1] Under consideration.

5 Testing

Before beginning the testing, all modules, including the control, shall be exposed to sunlight (either real or simulated) to an irradiation level of 5 $kWh \cdot m^{-2}$ to 5,5 $kWh \cdot m^{-2}$ while open-circuited.

The modules shall be divided into groups and subjected to the qualification test sequences in Figure 1, carried out in the order laid down. Each box refers to the corresponding subclause in this standard. Test procedures and severities, including initial and final measurements where necessary, are detailed in Clause 10.

NOTE 1 Where the final measurements for one test serve as the initial measurements for the next test in the sequence, they need not be repeated. In these cases, the initial measurements are omitted from the test.

In carrying out the tests, the tester shall strictly observe the manufacturer's handling, mounting and connection instructions. Tests given in 10.4, 10.5, 10.6 and 10.7 may be omitted if future IEC 61853 has been or is scheduled to be run on this module type.

Test conditions are summarized in Table 1.

NOTE 2 The test levels in Table 1 are the minimum levels required for qualification. If the laboratory and the module manufacturer agree, the tests may be performed with increased severities.

6 Pass criteria

A module design shall be judged to have passed the qualification tests, and therefore to be IEC type approved, if each test sample meets all the following criteria:

a) the degradation of maximum output power does not exceed the prescribed limit after each test nor 8 % after each test sequence;

b) no sample has exhibited any open circuit during the tests;

c) there is no visual evidence of a major defect, as defined in Clause 7;

d) the insulation test requirements are met after the tests;

e) the wet leakage current test requirements are met at the beginning and the end of each sequence and after the damp heat test;

f) specific requirements of the individual tests are met.

If two or more modules do not meet these test criteria, the design shall be deemed not to have met the qualification requirements. Should one module fail any test, another two modules meeting the requirements of Clause 3 shall be subjected to the whole of the relevant test sequence from the beginning. If one or both of these modules also fail, the design shall be deemed not to have met the qualification requirements. If, however, both modules pass the test sequence, the design shall be judged to have met the qualification requirements.

7 Major visual defects

For the purposes of design qualification and type approval, the following are considered to be major visual defects:

a) broken, cracked, or torn external surfaces, including superstrates, substrates, frames and junction boxes;

b) bent or misaligned external surfaces, including superstrates, substrates, frames and junction boxes to the extent that the installation and/or operation of the module would be impaired.

c) a crack in a cell the propagation of which could remove more than 10 % of that cell's area from the electrical circuit of the module;

d) bubbles or delaminations forming a continuous path between any part of the electrical circuit and the edge of the module;

e) loss of mechanical integrity, to the extent that the installation and/or operation of the module would be impaired.

8 Report

Following type approval, a certified report of the qualification tests, with measured performance characteristics and details of any failures and re-tests, shall be prepared by the test agency in accordance with ISO/IEC 17025. The report shall contain the detail specification for the module. Each certificate or test report shall include at least the following information:

a) a title;

b) name and address of the test laboratory and location where the tests were carried out;

c) unique identification of the certification or report and of each page;

d) name and address of client, where appropriate;

e) description and identification of the item tested;

f) characterization and condition of the test item;

g) date of receipt of test item and date(s) of test, where appropriate;

h) identification of test method used;

i) reference to sampling procedure, where relevant;

j) any deviations from, additions to or exclusions from the test method, and any other information relevant to a specific tests, such as environmental conditions;

k) measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate including temperature coefficients of short-circuit current, open-circuit voltage and peak power, NOCT, power at NOCT, STC and low irradiance, spectrum of the lamp used for the UV pre-screening test, maximum power loss observed after all of the tests, and any failures observed;

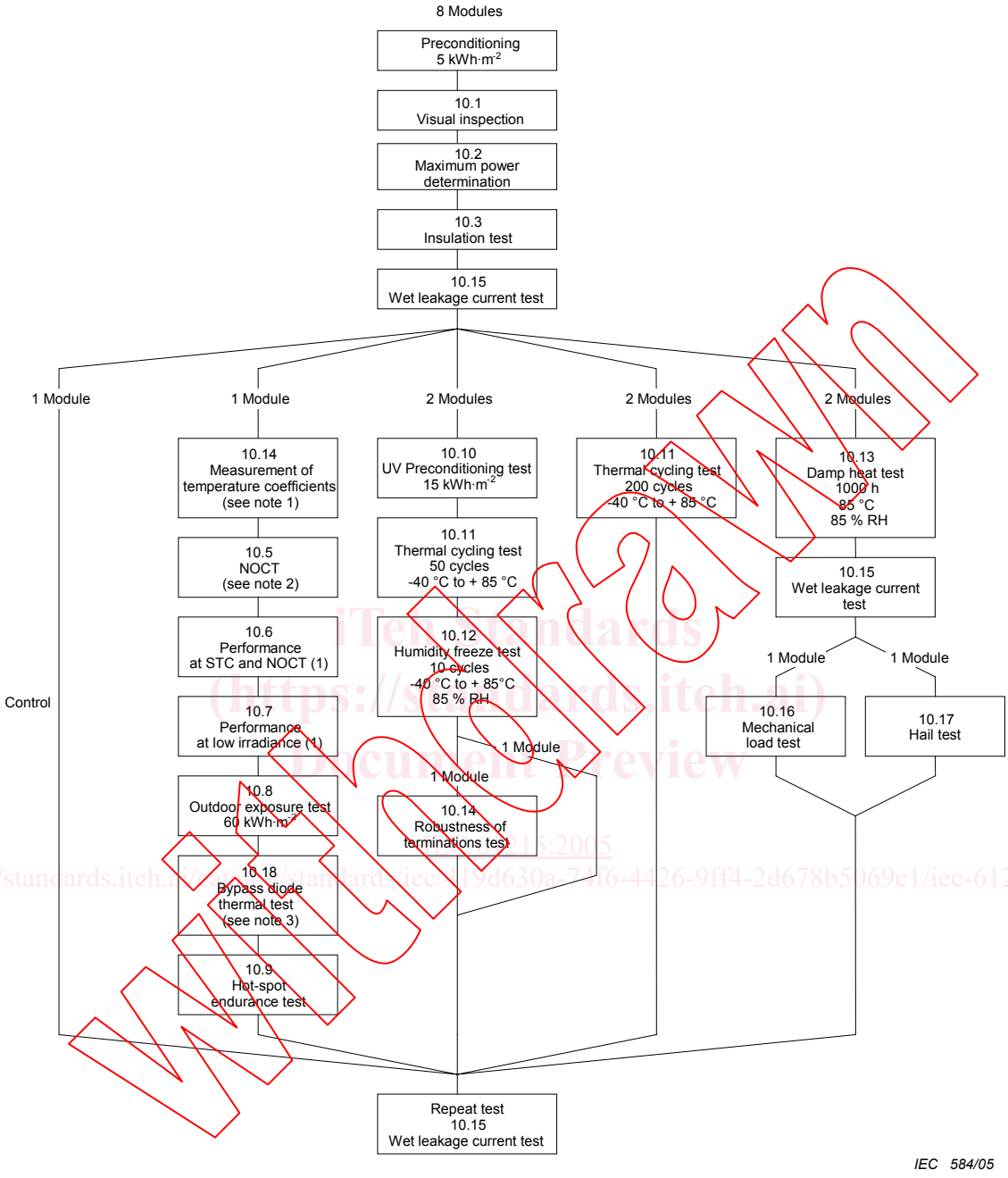
l) a statement of the estimated uncertainty of the test results (where relevant);

m) a signature and title, or equivalent identification of the person(s) accepting responsibility for the content of the certificate or report, and the date of issue;

n) where relevant, a statement to the effect that the results relate only to the items tested;

o) a statement that the certificate or report shall not be reproduced except in full, without the written approval of the laboratory.

A copy of this report shall be kept by the manufacturer for reference purposes.



NOTE 1 May be omitted if IEC 61853 has been performed.

NOTE 2 In the case of modules not designed for open-rack mounting, the NOCT may be replaced by the equilibrium mean solar cell junction temperature in the standard

Figure 1 – Qualification test sequence

Table 1 – Summary of test levels

Test	Title	Test conditions
10.1	Visual inspection	See detailed inspection list in 10.1.2
10.2	Maximum power determination	See IEC 60904-1
10.3	Insulation test	Dielectric withstand at 1 000 V d.c. + twice the maximum systems voltage for 1 min. For modules with an area of less than 0,1 m^2 the insulation resistance shall be not less than 400 MΩ. For modules with an area larger than 0,1 m^2, the measured insulation resistance times the area of the module shall be not less than 40 MΩ·m^2 measured at 500 V or maximum systems voltage, whichever is greater
10.4	Measurement of temperature coefficients (see note 1)	See details in 10.4 See IEC 60904-10 for guidance.
10.5	Measurement of NOCT (see note 1)	Total solar irradiance: 800 W·m^{-2} Ambient temperature: 20 °C Wind speed: 1 m·s^{-1}
10.6	Performance at STC and NOCT (see note 1)	Cell temperature: 25 °C and NOCT Irradiance: 1000 and 800 W·m^{-2} with IEC 60904-3 reference solar spectral irradiance distribution
10.7	Performance at low irradiance (see note 1)	Cell temperature: 25 °C Irradiance:200 W·m^{-2} with IEC 60904-3 reference solar spectral irradiance distribution
10.8	Outdoor exposure test	60 kWh·m^{-2} total solar irradiation
10.9	Hot-spot endurance test	Five-hour exposure to 1 000 W·m^{-2} irradiance in worst-case hot-spot condition
10.10	UV preconditioning	15 kWh·m^{-2} total UV irradiation in the wavelength range from 280 nm to 385 nm with 5 kWh·m^{-2} UV irradiation in the wavelength range from 280 nm to 320 nm
10.11	Thermal cycling test	50 and 200 cycles from –40 °C to + 85 °C with STC peak power current during 200 cycles
10.12	Humidity freeze test	10 cycles from + 85 °C, 85 % RH to –40 °C
10.13	Damp heat test	1 000 h at + 85 °C, 85 % RH
10.14	Robustness of termination test	As in IEC 60068-2-21
10.15	Wet leakage current test	See details in 10.15 For modules with an area of less than 0,1 m^2 the insulation resistance shall be not less than 400 MΩ. For modules with an area larger than 0,1 m^2 the measured insulation resistance times the area of the module shall be not less than 40 MΩ·m^2 to be measured at 500 V or maximum systems voltage, whichever is greater
10.16	Mechanical load test	Three cycles of 2 400 Pa uniform load, applied for 1 h to front and back surfaces in turn. Optional snow load of 5 400 Pa during last front cycle
10.17	Hail test	25 mm diameter ice ball at 23,0 m·s^{-1}, directed at 11 impact locations
10.18	Bypass diode thermal test	One hour at I_{sc} and 75 °C One hour at 1,25 times I_{sc} and 75 °C

NOTE 1 These tests may be omitted if future IEC 61853 has been performed on this module type.

9 Modifications

Any change in the design, materials, components or processing of the module may require a repetition of some or all of the qualification tests to maintain type approval.

10 Test procedures

10.1 Visual inspection

10.1.1 Purpose

To detect any visual defects in the module.

10.1.2 Procedure

Carefully inspect each module under an illumination of not less than 1 000 lux for the following conditions:

– cracked, bent, misaligned or torn external surfaces;
– broken cells;
– cracked cells;
– faulty interconnections or joints;
– cells touching one another or the frame;
– failure of adhesive bonds;
– bubbles or delaminations forming a continuous path between a cell and the edge of the module;
– tacky surfaces of plastic materials;
– faulty terminations, exposed live electrical parts;
– any other conditions which may affect performance.

Make note of and/or photograph the nature and position of any cracks, bubbles or delaminations, etc. which may worsen and adversely affect the module performance in subsequent tests.

10.1.3 Requirements

Visual conditions other than the major visual defects listed in Clause 7 are acceptable for the purposes of type approval.

10.2 Maximum power determination

10.2.1 Purpose

To determine the maximum power of the module before and after the various environmental tests. Repeatability of the test is the most important factor.

10.2.2 Apparatus

a) A radiant source (natural sunlight or a solar simulator class B or better in accordance with IEC 60904-9).